PRACTICAL

DISINFECTION

CIRCULAR

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NOTE.

The disinfection of infected premises is as important as the maintenance of a quarantine during the prevalence of the disease. The virus of contagious and infectious diseases will often live for years. It is imperative, therefore, that the infected premises, with its contents, be thoroughly disinfected immediately after the death or recovery of the patient, in order to avoid a spread of the disease.

A disinfection performed in the manner recommended in this circular, will be thoroughly effective. The work, however, must be properly done, as directed, else the disease may remain in the house, a menace to the health and lives of those who enter. The health officer should never forget the fearful consequences which may follow a neglect in any particular of this important duty.

Disinfection should be performed by the city, village, township or county authority—(the latter in counties not under township organization only—in territory outside of cities and villages)—under the immediate direction of or by a qualified health officer, or physician or embalmer licensed by the State Board of Health.

"Whatever measures are adopted should be made thorough.

"Measures, good or bad, half done are worse than useless, as they give a fancied security."

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PRACTICAL DISINFECTION.

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General Considerations.

The object of disinfection in the sick room is the destruction of infectious material attached to clothing, carpets, draperies, furniture or surfaces of the room, or deposited as dust upon the window ledges, in crevices, cracks, and other more or less inaccessible parts of the room. If the room has been properly cleaned and ventilated while still occupied by the sick person, and especially if it was stripped of carpets and unnecessary furniture at the onset of the attack, the difficulties of disinfection will be greatly reduced.

The work of disinfection should begin with the beginning of the treatment and should continue during the whole course of the disease. All articles of bed clothing and of body clothing should be disinfected as soon as they are removed from the bed or from the patient.

The liberal use of liquid disinfectants composed of chloride of lime, carbolic acid, or corrosive sublimate is strongly recommended in the sick room, but there should be no attempt to disinfect the room by any vapors or gases when occupied by the patient. This can not be accomplished. Fresh air, combined with absolute cleanliness, is the disinfectant most needed in the sick room.

During the entire illness the privy should be thoroughly disinfected with Standard Disinfectant No. 1, (see page 28) four or five gallons of which should be thrown into the vault every day. Instead of the solution, chloride of lime in powder can be used. All woodwork in the vault should be soaked with the solution or covered with powdered lime. Water closets and sinks should be disinfected daily by pouring a quart or more of the solution of chloride of lime or carbolic acid into the pipes. The pipes should be freely flushed in order to avoid injury.

As unsanitary surroundings and uncleanliness will tend to retard the recovery of the patient, every effort should be made to keep the house, cellar, outhouses and yard clean. The cellar should be freed of all rubbish and decaying matter and the walls whitewashed. All rubbish and decaying matter should be burned. Quicklime, Standard

Disinfectant No. 4, (see page 28) can be well used to whitewash exposed surfaces and to disinfect sinks, drains, decaying matter too wet to be burned, pools of water, etc. Attempts should be made to draw off all pools of water.

In the disinfection of houses which have been occupied by those suffering from contagious or dangerously communicable diseases, much can be accomplished by the liberal use of liquid disinfectants, by thoroughly washing all woodwork and exposed surfaces, and by the burning of mattresses and pillows, by the removal of wall paper after saturation with disinfectants, and by treating carpets, hangings and other fabrics and exposing them in the fresh air and to sunlight.

The ideal disinfection would be one which would have no destructive effect upon the contents of the room, which would have such penetrating power as to be effective upon all infectious materials however inaccessible they might be and which could be applied with a minimum of labor. Such a disinfectant has never been found. Gases are decidedly limited as to penetrating power and are suited only for comparatively superficial disinfection. Liquid disinfectants are unavailable for many uses. It is consequently essential that we adopt both the aerial and the liquid disinfectants, and that we give such attention to every detail that no article and no part of the room escape being subjected to the suitable disinfecting agent in the most advantageous way.

"Disinfectants, or germicides, are agents which bring about the destruction of bacteria in general and, more particularly, of those that act as the exciting causes of disease. While they are all to be classed as antiseptics, the latter, as a class, are by no means necessarily disinfectants, since many of them act simply to delay or prevent the action of fermentative agents, without exerting any destructive influence upon them. Cold, for example, is a most efficient antiseptic; but while it may inhibit growth and activity of micro-organisms, it does not necessarily deprive them of vitality."–Harrington.

AERIAL DISINFECTION.

The most effective part of house disinfection, however, is accomplished by the liberation of large quantities of disinfecting and germicidal gases, which impregnate the air, saturate the softer fabrics, and invade the most inaccessible and remote parts of the room. For this aerial disinfection the fumes of burning sulphur were formerly accepted by all health officers and sanitarians, but in more recent years formaldehyde gas has been used and exploited and has acquired a high degree of popularity.

Whatever the agent used for aerial disinfection with fumes or gases the following certain general rules are essential to success, and may be laid down for adoption both by those who adhere to sulphur as the disinfecting agent and by those who prefer and use formaldehyde gas.

(*a*) Have all windows and doors (except doors of egress) tightly closed. Securely paste strips of paper over keyholes, over all cracks, above, beneath and at sides of windows and doors, over stove holes, and all openings in walls, ceilings and floor. If the opening be large, paste several thicknesses of paper over it. Carefully stop up the fireplace, if there be one. There must be no opening through which gas can escape.

(*b*) All articles in the room that can not be washed should be spread out on chairs or racks. Clothing, bed covers, etc., should be spread on lines stretched across the room. Mattresses should be opened and set on edge. Window shades and curtains should be spread out at full length. If there is a trunk or chest in the room, open it, but let nothing stay in it. Open the pillows so that sulphur or formaldehyde fumes can reach the feathers. Do not pile articles together.

(*c*) After the aerial disinfection is completed and the room opened, take out all articles and place them in the sunshine. Carpets should be well beaten and exposed to the sun.

(*d*) All wood surfaces in the room should then be thoroughly washed with Standard Disinfectant No. 3. (see page 28.) Wash well all out-of-the-way places, window ledges, mouldings, etc. Floors particularly should receive careful attention and the solution should wet the dust and dirt in the cracks. If the walls are papered, soak the paper with the solution and have it removed.

(*e*) After washing, ventilate the rooms, if possible for several hours, then scrub all woodwork with soap and hot water.

(*f*) It is safer to burn mattresses and pillows.

(*g*) It is likewise safer to burn all books, toys and articles of little value which have been handled by the patient. Burn what you cannot boil or thoroughly wash. Books *which have not been in the room with the patient may be saved.* Lay them on edge of a table table with leaves open, in room while sulphur fumes or formaldehyde gases are being generated.

It must be borne in mind that thoroughness of application is most essential, whatever method of disinfection may be adopted. Carelessness in the slightest detail may be productive of the gravest danger to those whose confidence has been inspired by the assurances of safety.

Although the patient suffering from contagious disease may have been confined to one room, it must not be forgotten that the avenues for the transmission of infective material to other parts of the house are never entirely shut off so long as there is any communication between the sickroom and other rooms. Even the sheet, saturated with liquid disinfectants, which experience has taught us to hang over the open door of the sickroom, may not serve as a barrier to all infectious material, especially if the nurse, the physician and members of the family pass frequently from the sickroom to other parts of the house. Hence, after cases of particularly contagious nature, not only the sickroom but all rooms contiguous to it should be thoroughly disinfected.

Notes Concerning Insecticides.

A few words here regarding the agents which can be depended upon to destroy vermin will certainly not be out of place.

Some authorities have recommended formaldehyde as an insecticide. Those who have personally experimented with this agent know that it can not be depended upon to even kill mosquitoes in a room. Formaldehyde gas is but a feeble insecticide at best. It is never efficacious except when the gas is generated quickly and in large volume. Even then the results may be disappointing.

Formaldehyde has ordinarily but little penetrating power. Usually the gas will not reach the folds of bedding and clothing, and out-of-the-way places in which vermin are prone to hide.

As to sulphur, which is not only a reliable disinfectant, but also a powerful and reliable insecticide, the following remarks of Surgeon M. J. Rosenau, Director Hygienic Laboratory, U. S. Public Health Service, will be interesting:

"Sulphur dioxide is unexcelled as an insecticide. Very dilute atmospheres of the gas will quickly kill mosquitoes. It is quite as efficacious for this purpose when dry as when moist, whereas the dry gas has practically no power against bacteria. Contrary to formaldehyde it has surprising powers of penetration through clothing and fabrics, killing the mosquitoes, even when hidden under four layers of toweling, in one hour's time—and with very dilute proportions.

"This substance, which has so long been disparaged as a disinfectant because it fails to kill spores, must now be considered as holding the first rank in disinfection against yellow fever, malaria, filariasis, and other insect-borne diseases."

SULPHUR DISINFECTION.

Disinfection by the burning of sulphur has been successfully practiced for many years. As stated by Surgeon General Sternberg, United States Army, "the experience of sanitarians is in favor of its use in yellow fever, small-pox, scarlet fever, diphtheria and other diseases in which there is reason to believe that the infectious material does not contain spores." This method of disinfection has also been endorsed recently by the United States Marine Hospital Service, after numerous experiments, during which the efficacy of sulphur disinfection, in the presence of moisture, was conclusively proven.

The results obtained by the Illinois State Board of Health, in the several experiments made, have been directly in line with those of other investigators. The burning of sulphur in the presence of moisture has been found an effectual method of gaseous disinfection, and one upon which entire dependence can be placed *at all times* in disinfection after diseases due to micro-organisms not containing spores.

After the preparation of the room, as described on page 7, reliable and cheap disinfection may be secured by the following method of the use of sulphur.

(1) Use three pounds of powdered sulphur for every 1,000 cubic feet in the room. A room ten feet long, ten feet wide and ten feet high has 1,000 cubic feet. For a large closet use two pounds of sulphur.

(2) Burn the sulphur in an iron pot or deep pan. Let the pot or pan stand in a larger vessel containing water, which vessel should be placed on a table, not on the floor. For example, take a common wash tub, lay in it three or four bricks, pour in boiling water to the level of tops of bricks, put the pot or pan containing the required amount of sulphur on the bricks, place the wash tub and contents on a table. The disinfecting "apparatus" is then in working order.

(3) Moisten the sulphur with alcohol and ignite. When the sulphur begins to burn, leave the room, close the door of egress, and carefully paste strips of paper over the keyhole and all openings above, beneath and at sides of door. Keep the room closed for ten hours at least, twenty-four if possible.

Sulphur candles may be used instead of crude sulphur, but care must be taken to use sufficient candles. The average candle on the market contains one pound of sulphur. Three of these will be required in the disinfection of a small room 10x10x10. Do not use a less number, no matter what directions may accompany the candle. The water-jacketed candle is preferable. Partly fill tin around candle with water and place candles in a pan on the table, not on the floor.

Let at least one-half pint of water be evaporated with each candle. Evaporate more if practicable. In the absence of moisture, the fumes of sulphur have no disinfecting power.

There is, however, one serious objection to the use of sulphur, and this must be fully understood. The fumes of sulphur (sulphurous acid) have a destructive action on the fabrics of wool, silk, cotton and linen, on tapestries and draperies, and exercise an injurious influence on brass, copper, steel and gilt work. Colored fabrics are frequently changed in appearance and the strength impaired. Fabrics, however, can be effectually disinfected by hanging them on a line exposed to the sun and wind for several days. Curtains and all articles of cotton or linen, boiling or soaking them in Standard Disinfectant No. 3, for several hours, and portable articles of brass, copper, steel and gilt work by washing with a strong solution of carbolic acid (Standard Disinfectant No. 1). Colored fabrics which have been in a room during disinfection should be immediately exposed to the sun and wind. Uncolored fabrics which will not be injured by moisture should be at once soaked in water. This action will prevent further injurious action of the sulphuric acid.

Sulphur will be found a thoroughly reliable gaseous disinfectant of considerable penetrating power, if it is intelligently employed. To obtain satisfactory results, the following essentials of successful disinfection, established by repeated experiments, must be observed: (*a*) The infected room, or rooms, must be thoroughly closed, every crack and crevice sealed. (*b*) Sufficient sulphur must be used. (*c*) There must be moisture in the room, (*d*) The time of exposure must be sufficient, ten hours the minimum.

In the disinfection of stores, halls, school houses and apartments or dwellings, in which there are no articles to be injuriously affected by the gas, sulphur is an ideal disinfectant. Its mode of application is simple (the simpler the mode of application the better), it is cheap, the material is accessible everywhere, and, finally, the most important of all, the action will be invariably found effective when the sulphur is properly used.

"Cleanliness is an important adjunct to the work of disinfection.

* * * * * * *

"Cleanliness accomplishes another important purpose as far as infection is concerned; it removes the organic matter on which and in which the bacteria find favorable conditions for prolonging life and virulence."—Rosenau.

FORMALDEHYDE DISINFECTION.*

On account of the destructive properties of sulphur, efforts have been made to find a satisfactory substitute for this agent, one of equal germicidal power, which will not damage the contents of the room. If dependence could be placed on the published results of innumerable experiments made with formaldehyde, there would be no necessity for further search for the much desired substitute. Formaldehyde has been lauded as the most powerful sterilizer and germicide known; as a gaseous disinfectant far superior in efficiency to sulphur—one seemingly without limitations, effective at all times. The results obtained by careful observers in experiments made, not in laboratories, but in dwelling houses, shops and railroad cars, in which disease is often found, do not substantiate the extravagant claims made for formaldehyde.

Formaldehyde (otherwise known as methyl aldehyde, formicaldehyde and "formalin") exists in several forms, but is principally known as a gas. Its germicidal properties were not recognized until 1886. and were not put to use until 1890. The formaldedyde gas is the vapor of wood alcohol which has undergone a chemical change. The gas is produced by passing the vapor of wood alcohol over platinum or platinized carbon in an incandescent state. Many portable apparatus for the production of formaldehyde gas directly from wood alcohol have been devised during the past ten years. The writer made a series of experiments in 1896-7, while connected with the Chicago Health Department, with the lamps then on the market. The tests were conducted in the most painstaking and careful manner, but in every instance the results were unsatisfactory. It was found that the lamps did not give off sufficient formaldehyde; that the alcohol was generated too slowly, and that large quantities of alcohol passed through the lamp unchanged. But few bacteria were killed by the gas evolved. There was consequently no disinfection. Not one of these lamps so highly endorsed in 1896 as ideal apparatus for the production of formaldehyde gas is now offered for sale. Experiments were made at the same time under the best possible conditions with the generator in which the fluid formaldehyde was boiled and vaporized. Disinfection failed in nearly all these experiments.

In 1898 the State Board of Health commenced experiments for the purpose of confirming or disproving the many claims made for formaldehyde by sanitary authorities at home and abroad, and incidentally for the purpose of finding a practical method of disinfection with this agent. These experiments were made under the direction

* See page 15 for method recommended.

of Professor T. J. Burrill, of the University of Illinois, and were continued at intervals until 1902. The results of the experiments are as indicated below.

The aqueous solution of formaldehyde gas, known as formaldehyde and "formalin," is a 40 per cent solution of the gas formaldehyde in water. It is claimed that many of the commercial preparations do not contain 40 per cent of formaldehyde. Several processes have been devised for the liberation of formaldehyde gas from its watery solution. The solution when exposed to the air gives off a considerable quantity of the gas, especially when sprayed on large surfaces. If the solution be sprayed on blankets or sheets or articles of clothing hung in the room or on the walls, the liberation of the gas will be so rapid as to compel the operator to leave the room. These facts have given rise to the belief that exposure of the gas in this manner will be sufficient to cause disinfection. The results, however, do not confirm this. There is much uncertainty as to the amount of gas which is evolved, and the behavior of the gas is at times capricious.

It has been determined by the United States Public Health Service after a series of extended experiments conducted by Past Assistant Surgeon M. J. Rosenau, that formaldehyde sprinkled on blankets and sheets has practically no disinfecting power in a closed box, excepting on the spot where the solution falls; this after a twenty-four exposure.

The amount of gas given off from the aqueous solution of formaldehyde at ordinary temperatures is exceedingly small. After the solution has been applied to exposed surfaces, the liquid becomes concentrated, and as found years ago by Surgeon J. J. Kinyoun of the United States Public Health Service, the greater proportion of the formaldehyde gas is converted into a yellowish white amorphous substance known as trioxy-methelene. In this state it gives off but a slight amount of formaldehyde.

The State Board of Health conducted a number of experiments during the years 1899-1902 to test the efficiency of the so-called "sheet method" of disinfection, which consists of suspending sheets in the infected room, and spraying them with a solution of formaldehyde, using about six ounces of the forty per cent. solution to each thousand cubic feet of air space. The results with this method have not been satisfactory. At times under favorable conditions the method proved effective, while again under almost identical conditions, it was found worthless, even when the amounts of formaldehyde on the areas of sheet surface were increased. At temperatures below 60° F. the results were invariably unsatisfactory.

To ensure good results with this method it is absolutely necessary that the sheets be sprayed evenly in small drops over the entire surface, care being taken not to go over the same surface twice. Even the most enthusiastic advocates of the "sheet method" admit that the results will be unfavorable unless this precaution be observed. Formaldehvde is exceedingly irritating to the respiratory passages and to the eyes, so that it becomes a test of human endurance to remain in a room for the time necessary to properly spread sufficient solution to

disinfect a very small space, while in a room of ordinary dimensions, which would require a number of sheets, the proper spreading of the solution by one man becomes a matter of absolute impossibility.*

The ordinary disinfector working under conditions so decidedly unpleasant will, in the majority of instances, slight his work, so that even if the sheet method were much more efficient than it is, the results of its practical application would seldom be satisfactory.

These conclusions have been reached by different State Boards of Health throughout the country, which have made personal investigations into the efficacy of this mode of disinfection.

Rosenau, of the United States Public Health Service, says, that the "sheet method" has distinct limitations and unless all necessary conditions are carefully observed, is very untrustworthy. The gas is given off very slowly and in very uncertain quantity, diffuses poorly in dead spaces and is entirely inapplicable to large enclosures. Even when conducted with the utmost care, the method is limited to rooms not exceeding 2,000 cubic feet.

In view of the fact that it is practically impossible for a disinfector to properly spray the sheets, over a sufficient area to have effect in rooms of more than small dimensions; in view of the fact that there will be no disinfection unless the sheets be properly sprayed; in view of the fact that the method is utterly worthless at even reasonably low temperatures, and further in view of the unreliability of the method, indicated in the numerous failures to kill bacteria, even of feeble resisting powers, when technique seemed perfect and conditions favorable, the Illinois State Board of Health can not recommend its use to physicians or health authorities. "An effective method of disinfection must have no exceptions; it must invariably kill."

The most common method of obtaining formaldehyde gas from the watery solution at the present time is by means of apparatus designed to regenerate the gas by boiling the solution under pressure. Many generators operating on this principle are to be found on the market. Several of these are complicated machines requiring skill to properly operate. As some of the generators require constant attention, it has been found necessary to place them outside of the apartment being disinfected and to pass the gas into the room by means of a tube run through a keyhole. The diffusion of the gas produced in this way is slow, particularly in large areas, tending to its concentration at a few points and to the formation of paraform. This method of disinfection cannot be recommended. To insure a perfect disinfection with formaldehyde it is necessary that the gas be liberated quickly and in large volume.

Formaldehyde "candles" composed of paraform are now offered to health authorities as a means of disinfection. No dependence whatever should be placed on these candles.

* Laboratory Investigations. * * * Spraying a sheet with formaldehyde while the operator is standing in front of the sheet is a procedure claimed to be possible only by those who have never tried it, and describe it from imagination. * * After ten ounces had been sprayed further operation was rendered impossible by the unbearable, irritating vapor of the formaldehyde; * * Disinfection not obtained in experiments conducted;—*Bulletin of the Pathological and Bacteriological Laboratory of the Delaware State Board of Health.*

The evaporation of the solution of formaldehyde by the means of heat in an ordinary kettle is one of the simplest methods of disinfection with formaldehyde, and the results have proven effective. This method was endorsed by the writer in 1896. This is termed the Breslau method. Many health authorities have testified to its efficiency during the past eight years. To quote from the monthly report of the Chicago Health Department of January, 1898, in which this process is described at length and heartily endorsed: "A six hours' exposure under these conditions has given better results in the sterilization of cultures than has been obtained by any other method, and the other requirements—of simplicity and portability of apparatus, rapid evolution of the disinfecting agent and brief duration of exposure, together with reasonable cost of disinfection—are very nearly met."

A very simple apparatus for disinfection by this method was devised by the Health Department of St. Louis in 1898. This consists of a copper kettle for the disinfectant, a tripod, and a copper vessel containing mineral wood for the alcohol. When the apparatus is placed in order the kettle is partly filled with hot water and the alcohol in the vessel beneath is ignited. As soon as the water boils there is poured into the kettle a quantity of the 40 per cent solution of formaldehyde, forty ounces being sufficient for the disinfection of 2,000 cubic feet of air space. In order to produce sufficient moisture, there is used in addition a similar apparatus in which water alone is boiled. The State Board of Health conducted many experiments with this apparatus, and the results have been generally satisfactory, and it is evident that the apparatus, when properly used, can, under favorable conditions, be relied upon to produce a proper amount of formaldehyde gas of the highest efficiency. After repeated tests made at intervals from 1899 to 1901, the Board feels justified in endorsing this method of disinfection with formaldehyde, with a proper apparatus.

To obtain proper results with this or any other apparatus it is absolutely necessary that the *best* formaldehyde or formalin be obtained Much of the formaldehyde sold in the United States under different names cannot be relied upon. To be effective formaldehyde must contain not less than 38 per cent of strength. There is also much difference in the quality of wood alcohol found on the market. Alcohol 95 per cent proof must be used in this apparatus.

The best imported formaldehyde (formalin) was used in all the experiments conducted by the Illinois State Board of Health.

In disinfection with formaldehyde the same precautions relative to the sealing of the room should be taken as in disinfection with sulphur. It must be borne in mind also that the gas of formaldehyde, unlike like that of sulphur, has but feeble penetrating power. There is no doubt, however, that the gas of formaldehyde will penetrate wherever infection has been carried by the surrounding atmosphere.

THE FORMALDEHYDE AND POTASSIUM PERMANGANATE METHOD OF GENERATING FORMALDEHYDE GAS.

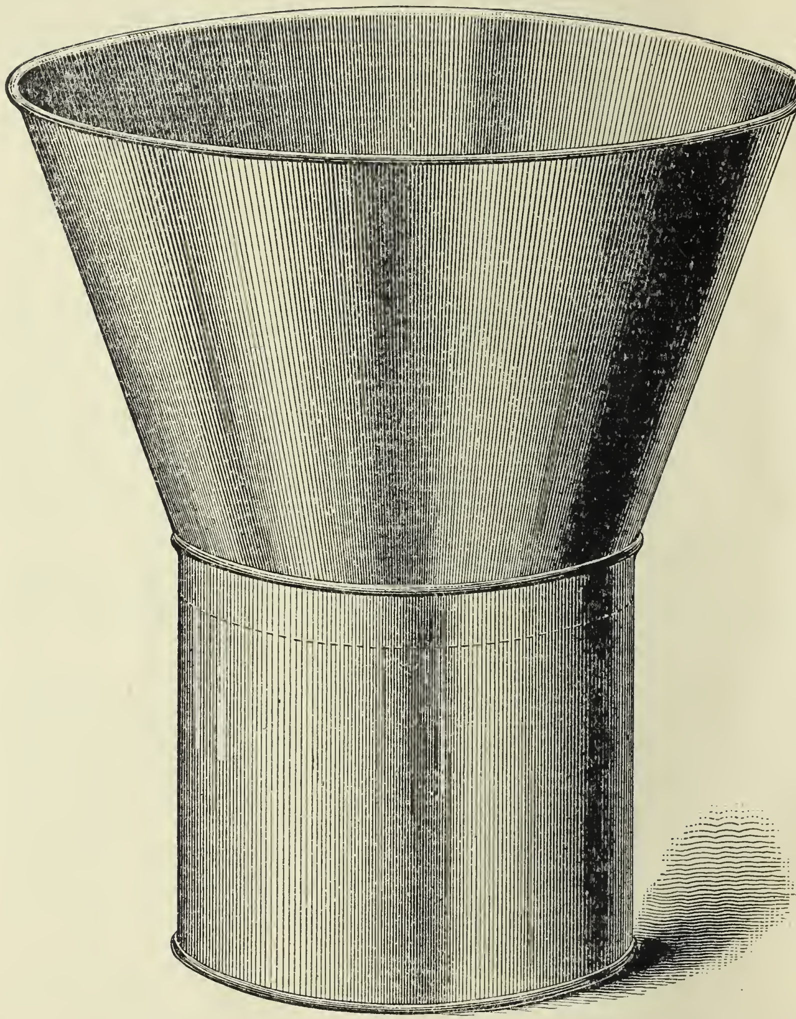
The Method Recommended.

While the results obtained with some of the methods of formaldehyde disinfection formerly suggested have been generally satisfactory, failures were at times experienced when the conditions were apparently ideal, while under unfavorable conditions of temperature and humidity, ineffective disinfection was of frequent occurrence. For this reason, while placing before the physicians and health officers of the state the best methods of formaldehyde disinfection, the State Board of Health has continued to advocate sulphur for aerial disinfection as the only agency which had demonstrated beyond question its efficiency and reliability at all times.

Aside from the uncertainty of results of the methods of formaldehyde disinfection offered for use, the apparatus has often been complicated in operation, unnecessarily expensive and dangerous as to destruction of property by fire.

An exceedingly simple method of generating the gas by pouring formaldehyde solution over the crystals of potassium permanganate in an open vessel, has been more recently suggested and gave promise of overcoming the objections which have stood in the way of the more general adoption of formaldehyde as a disinfecting agent. This method primarily offered the advantages of absolute simplicity in operation, requiring no special apparatus and no fire. In addition to this, exhaustive experimental work has demonstrated that, in practical disinfection, the method is unusually efficient, the effectiveness seeming to depend less upon the conditions of humidity and temperature than that of any other method.

The only apparatus required is a large open vessel, protected by some non-conductive material to preserve the heat within. An ordinary milk pail, set into a pulp or wooden bucket will answer every purpose, although a special container, devised for physicians and health officers, will be found of considerable advantage. This container or generator consists of a simply constructed tin can with broad flaring top. Its full height is 15½ inches, the height of the flaring or funnel-shaped top being about 8 inches. The lower or round section is 10 inches in diameter, while the funnel top is 17½ inches in diameter at the top. This container is made of a good quality of tin, is supplied with a double bottom with a layer of asbestos between the layers of tin, and is entirely covered on the out-



DISINFECTING APPARATUS.

(Designed by the Maine State Board of Health.)

Height, 15½ inches; height of lower portion, 8 inches; diameter at top, 17½ inches; diameter at base, 10 inches. Made of bright tin and covered with asbestos paper.

side with asbestos paper. The asbestos paper and double bottom serve to effectively retain the heat which is generated by the vigorous chemical reaction occurring within the generator, and which is essential to the complete production and liberation of the gas. The special retainer can be made by any tinner of ordinary intelligence, and costs but a few dollars.

This method of aerial disinfection was first suggested in 1902-3, but it was given no publicity until 1904, when it was described by Dr. G. A. Johnson, of Sioux City, Iowa, in a paper read before the Sioux Valley Medical Association. Even then it attracted very little attention and was not subjected to systematic tests until late in 1904, when numerous experiments were made by the Maine State Board of Health.

The test-bacteria used in the experiments of the Maine board were diphtheria, typhoid, staphylococcus albus and aureus, coli communis, pyocyaneus, tetragenus, streptococci, anthrax, subtilis, and mixed cultures mostly from swabs from the throats of patients thought to have diphtheria. The time of exposure was at first 16 hours, but this was gradually reduced to 3 hours with no lessening efficiency.

Of the 1,529 test objects exposed in 279 experiments, only twenty-seven showed a growth after incubation for at least 48 hours. Of these twenty-seven unsuccessful results, twenty-one were with the exceedingly resistant hay bacillus (B. subtilis). None of the bacilli of diphtheria, typhoid fever or other ordinary pathogenic germs survived the exposure to formaldehyde.

While placing great dependence on the results obtained by the Maine State Board of Health, the Illinois State Board of Health decided to pursue the policy adhered to since 1898, to make a systematic test of all methods of disinfection recommended before endorsing or condemning the methods.

During the summer and autumn of 1905 exhaustive experimental investigations were carried on with this method of disinfection in the laboratories of the State Board of Health at Springfield. An ordinary office room, containing 1,080 cubic feet of air space, was secured, situated conveniently to the laboratory. The door was carefully sealed with strips of gummed paper and access to the room was gained through an outer window. This window was not protected by paper strips, but set closely in its frame.

Twenty-four (24) hour bouillon cultures of various forms of bacteria were prepared. Strips of milk paper ($\frac{1}{2}$ in. x 2 in.) were saturated with these cultures. The slips were saturated in pairs, one slip being exposed to the fumes of the gas in the room, the other placed in a sterile envelope, sealed, labeled and kept in the laboratory to be used as a control. After the exposure of the first slip to the fumes of the gas generated by pouring the 40% formaldehyde solution over the permanganate of potassium in the usual manner, it was returned to the laboratory, both slips placed each in a tube of sterile bouillon, incubated at 37° C. for 48 hours, and later examined and compared.

On account of the variable results obtained by other methods of formaldehyde disinfection, depending largely upon the temperature

and atmospheric conditions, days were selected for experimental work which varied greatly in temperature, humidity, cloudiness and other climatic conditions, and these conditions were made a part of the laboratory records.

Specimens were exposed for a period of 6 hours and, between experiments, the room was left open that it might be entirely freed of any traces of formaldehyde gas.

The results of experiments of the Illinois State Board of Health are shown in the tables on pages 19 and 20.

It will be noted in the tables of laboratory tests that the bacterial growth was entirely destroyed when one quart (32 oz.) of formaldehyde was used to the 1,000 cubic feet of air space, and that equally satisfactory results were obtained with one pint (16 oz.) of formaldehyde. It may consequently be stated that, under ordinary conditions of house disinfection, the room being well sealed, a pint (16 oz.) of formaldehyde solution with 6¾ oz. of potassium permanganate will be ample for 1,000 cubic feet of air space. With these amounts bacterial cultures, enclosed in from one to four layers of 4½ oz. flannel, were destroyed, these cultures including the bacillus subtilis (hay bacillus) known to be especially resistant to formaldehyde gas. It is not yet determined how small quantities of formaldehyde and permanganate of potassium will produce satisfactory results, but it is the part of wisdom not to economize in materials if there is the slightest danger of reducing the germicidal power. Even with the largest quantities named, a quart of formaldehyde to 13½ oz. of potassium permanganate, the cost is small.

It might be noted in this connection that the Maine State Board of Health adopted in its experiments the proportion of 6½ oz. of potassium permanganate to 32 oz. of formaldehyde for each 1,000 cubic feet of air space, and in a recent circular still recommends these amounts. However, as stated above, it has been the experience of the Illinois State Board of Health that under proper conditions, (at temperatures above 60° F.) one pint (16 oz.) of formaldehyde (the 40% solution) with 6¾ oz. of potassium permanganate will be sufficient for the disinfection of 1,000 cubic feet of room space.

The results obtained with this method, in experiments conducted by the Illinois State Board of Health, under varying atmospheric conditions and with a rather wide range of temperature, indicate that there has been finally found a method of formaldehyde disinfection which will prove effective under reasonable conditions, at temperatures ordinarily found in the living or sleeping rooms, while the simplicity, the small expense of apparatus (in fact, its successful operation without apparatus of any kind, if necessary) and the moderate cost of operation, serve to commend it. In the work of the State Board of Health the best quality of imported formaldehyde (formalin) was employed, and Merck's potassium permanganate, but even with the highest grade of materials the cost is small.

It must be borne in mind that the quantities of potassium permanganate and formaldehyde set forth above, should be used only

RESULTS OF EXPERIMENTS AT ORDINARY TEMPERATURES.

Formaldehyde—Potassium Permanganate Method.

Number of experiment.	Weather.	Formaldehyde per 1,000 cubic feet	* Mean Temperature	Bacillus Coli Communis	Bacillus Typhosus	Bacillus Prodigiosus	Bacillus Anthracis	Pneumococcus	Streptococcus	Staphy. Pyogenes Albus	Staphy. Pyogenes Aureus	Staphy. Pyogenes Citreus	Bacillus Subtilis
1	Precipitation, 0— Clear	32 ounces	84 F R. 82 F	Neg.	Neg.	Neg.	Neg.	....	....	....	....	....	....
2	Precipitation, 0.12— Partly cloudy	32 ounces	83 F R. 81 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	....
3	Precipitation, trace— Cloudy	32 ounces	78 F R. 80 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	....
4	Precipitation, trace— Partly cloudy	32 ounces	72 F R. 76 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	....
5	Precipitation, 0— Partly cloudy	32 ounces	73 F R. 75 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	....
6	Precipitation, 0— Partly cloudy	32 ounces	70 F R. 75 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
7	Precipitation, 0.01— Cloudy	32 ounces	69 F R. 71 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
8	Precipitation, 0.07— Cloudy	32 ounces	70 F R. 68 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
9	Precipitation, 0— Partly cloudy	32 ounces	73 F R. 69 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
10	Precipitation, 0— Clear	32 ounces	72 F R. 73 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
11	Precipitation, 1.53— Cloudy	32 ounces	71 F R. 70 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
12	Precipitation, 0— Clear	32 ounces	77 F R. 75 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
13	Precipitation, 0— Clear	32 ounces	78 F R. 78 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
14	Precipitation, 0— Clear	32 ounces	78 F R. 76 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
15	Precipitation, 0— Partly cloudy	32 ounces	82 F R. 80 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

* Temperature indicated by "R" is the temperature of the room.
Temperature first given is out of door temperature.
Neg.—No growth.

RESULTS OF EXPERIMENTS AT ORDINARY TEMPERATURES—*Concluded.*

Formaldehyde—Potassium Permanganate Method.

Number of experiment	Weather.	Formaldehyde per 1,000 cubic feet	* Mean Temperature	Bacillus Coli Communis	Bacillus Typhosus	Bacillus Prodigiosus	Bacillus Anthracis	Pneumococcus	Streptococcus	Staphy. Pyogenes Albus	Staphy. Pyogenes Aureus	Staphy. Pyogenes Citreus	Bacillus Subtilis
16	Precipitation, 0— Clear	24 ounces	77 F R. 76 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
17	Precipitation, trace— Partly cloudy	24 ounces	70 F R. 77 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
18	Precipitation, trace— Partly cloudy	24 ounces	70 F R. 76 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
19	Precipitation, 0— Clear	24 ounces	76 F R. 75 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
20	Precipitation, 0.22— Partly cloudy	24 ounces	67 F R. 78 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
21	Precipitation, 0.21— Cloudy	16 ounces	60 F R. 65 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
22	Precipitation, 0— Cloudy	16 ounces	72 F R. 70 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
23	Precipitation, 0— Clear	16 ounces	72 F R. 70 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
24	Precipitation, 0.01— Cloudy	16 ounces	66 F R. 65 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
25	Precipitation, 0.01— Cloudy	16 ounces	70 F R. 68 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
26	Precipitation, 0.11— Partly cloudy	16 ounces	67 F R. 69 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
27	Precipitation, 0— Clear	16 ounces	71 F R. 66 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
28	Precipitation, 0— Clear	16 ounces	67 F R. 70 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
29	Precipitation, 0— Clear	16 ounces	63 F R. 66 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
30	Precipitation, 0.01— Cloudy	16 ounces	68 F R. 66 F	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

* Temperature indicated by "R" is the temperature of the room.
Temperature first given is out of door temperature.
Neg.—No growth.

when the temperature of the room to be disinfected is 60° F. or higher. The quantities to be used at lower temperatures are stated on page 27.

In this method of disinfection the following rules should be observed:

The room should be sealed and prepared in the manner described on page 7.

The permanganate ($6\frac{3}{4}$ oz. for each 1,000 cubic feet of room space) should be first put in the apparatus or generator.

The formaldehyde solution (16 oz. for each 1,000 cubic feet of room space) should be then poured on the permanganate.

The permanganate must go in first.

As the formaldehyde gas is promptly liberated by the vigorous chemical reaction of the formalin and the potassic salt, and rises from the container in an immense volume, it is essential that all preparations be made in advance, and that the operator leave the room at once on the combination of the two chemicals. The door or window of exit should be promptly closed and sealed, and the room left closed for six hours.

The room should be thoroughly cleaned after disinfection. All out-of-the-way places, window ledges, mouldings, etc., should be washed with Standard disinfectant No. 3. (See page 28.) The floors of the sick room should receive careful attention, and the solution should wet the dust and dirt in the cracks.

The Generator:—A few words as to the generator or apparatus required in this method of disinfecting. Whenever practicable the apparatus described on page 16, should be employed. The State Board of Health recommends that health officers keep a number of these on hand ready for immediate use.

When this apparatus cannot be obtained, use can be made of a milk pail. It is necessary that the top of the apparatus flare out like a funnel, so a milk pail should be selected. The pail can be set in a pulp or wooden bucket, if it fits snugly. If not it would be better to tightly wrap the sides and cover the bottom with two layers of asbestos paper, or, if this cannot be got, with layers of blanket. It is absolutely necessary that all possible heat be retained in the generator, hence the necessity for a covering.

Capacity of Generator—Care must be taken not to put too much of the formaldehyde solution in the generator. Unless this precaution be observed, the solution will boil over and be wasted, besides causing a possible damage where it falls.

The following are the maximum quantities of the chemicals which can be safely used in the containers recommended by the State Board of Health:

Ten or 12 quart milk pail—	Formaldehyde, 16 oz.
	Permanganate, 6¾ oz.
Fourteen quart milk pail—	Formaldehyde, 24 oz.
	Permanganate, 10 oz.
Apparatus on page 16 —	Formaldehyde, 32 oz.
	Permanganate, 13½ oz.

FORMALDEHYDE AND POTASSIUM PERMANGANATE METHOD OF DISINFECTION.

Results at Low Temperatures.

As stated in the first edition of this circular, which was issued at the conclusion of the experiments in practical disinfection undertaken in 1905, it had been the experience of the State Board of Health that formaldehyde, however generated, often failed to accomplish satisfactory disinfection if used at a temperature below 60° F. This had been the personal experience of the secretary in 1896-1897, when he tested the Robinson, Moffatt, Kny-Scherer and Hollister lamps and the Trillat and the Sanitary Construction Company's autoclaves, constituting all forms of apparatus on the market at that time. In these earlier experiments some of the test organisms were killed when the room temperature was sufficiently high, but there was uniform growth of cultures when the temperature was below 60° F. It then appeared that, as with chlorine, the germicidal power of formaldehyde was increased by high temperature and was materially reduced by cold.

These early results were confirmed in the exhaustive tests made by the State Board of Health from 1898 to 1902, and it was then apparent that the action of the gas was modified not only by temperature and humidity, but by some other factors not fully understood.

While the experimental work of the State Board of Health of 1898-1902 led to the establishment of a method of formaldehyde disinfection which was satisfactory under ordinary conditions (See p. 14), many of the problems of aerial disinfection with formaldehyde remained unsolved. Neither the question of proper temperature nor of proper humidity could be satisfactorily settled, and as the majority of investigators adhered to the belief that disinfection with formaldehyde was impracticable at low temperature, the Illinois State Board of Health deemed it the part of wisdom to advise the use of sulphur at any temperature below 60° F.

It might be appropriately stated here, that in the 279 experiments conducted by the Maine State Board of Health, the temperatures varied from 67° F. to 80° F.

It would appear in the light of the results of the experiments undertaken in 1906 by the Illinois State Board of Health, that successful disinfection with formaldehyde is not so much a question of either temperature or humidity as one of the proper method of the generation of the gas. The results of the most recent experiments are tabulated on page 25, and these show that as satisfactory results were obtained at a temperature of 20° below the freezing point as at midsummer heat; and on seemingly unfavorable days as on those when perfect disinfection might be looked for.

These facts were clearly demonstrated in the first fifteen of the recent experiments, (Experiments Nos. 1 to 15, page 25) in which the ordinary bacterial tests were carried out with the utmost accuracy by two thoroughly competent bacteriologists, who personally superintended every detail of the work, from the preparation of the cultures to the final laboratory examination, including the preparation of the test-room and the generation of the formaldehyde gas. The final tests (Experiments 1-5, page 26), show results that are even more convincing and gratifying, as in these experiments the gas was put to the severest disinfecting tests suggested from any quarter.

For the purposes of experimental disinfection, an ordinary office room having a capacity of 3,500 cubic feet was secured. This room contained two large windows and one door, and these, fitting rather snugly, were not sealed in any of the tests. In the first fifteen experiments, strips of bibulous (milk) paper saturated with twenty-four hour bouillon cultures were used, and exposed at various heights in different parts of the room. These slips were kept in the room for six hours during the liberation of the formaldehyde gas and were then taken to the laboratory in tubes of sterile bouillon. These tubes, together with tubes inoculated with control culture slips, which were used in every instance, were then placed in the incubator for a period of forty-eight hours. It may be noted that bacteria of the most resistant character were used, and further, that cultures made from the control slips invariably showed profuse and healthy bacterial growths.

The almost entirely uniform results of these experiments, consisting of 80 culture tests, taken with the 290 culture tests made in 1905, indicate conclusively that we now have, in the potassium permanganate-formaldehyde method of disinfection, one which is easily applied, which is of almost nominal expense, and one upon which we may place dependence at all times and under all conditions.

That the method should be subjected to the severest tests however, an effort was made to ascertain those conditions which, in the opinion of competent observers, were liable to lead to failure or to unsatisfactory results in practical disinfection, and the final tests shown on page 26 were made under those conditions. Various writers had questioned the power of formaldehyde to penetrate cloth, hangings or drapings: others had doubted the disinfecting powers of formaldehyde on articles in the lower-most parts of the room, especially when covered with carpet or matting. Dr. Hibbert Winslow Hill, of the Minnesota State Board of Health Laboratories had cited (*) as sources of error in testing gaseous disinfectants, the following points: (*a*) That freshly dried bacterial cultures are more highly resistant than moist specimens or those dried a week or more. (*b*) That freshly dried specimens (24, 48, 72 and 96 hours), particularly, if dried on hard material are especially resistant.

It will be noted that in the final group of experiments this method of disinfection was subjected to the severest tests under most unfavorable conditions, but in spite of this the results differed little if

*The Journal of Infectious Diseases, Sup. No. 2, February, 1906, page 210.

at all from the former tests. Hard-wood butchers' skewers were used in all of the final tests as well as milk paper slips and the cultures on these skewers and slips were dried 24, 48, 72 and 96 hours. The results were eminently satisfactory. The results with the freshly dried specimens, dried on hard material, were remarkable when we consider that the exceedingly resistant bacilli (*B. anthracis and B. subtilis*) failed to survive.

The paper slips were placed under carpets and others wrapped in four or five layers of flannel, and while the results in these tests were not all negative they were such as to indicate that formaldehyde gas, properly generated, has greater penetrating power than formerly believed. The only absolute failures in disinfection were in those tests in which culture slips were placed between the leaves of books, and, in such instances, bacterial destruction could not reasonably be looked for.

These results certainly corroborate the previous findings of the State Board of Health.

Quantities of Chemicals:—In view of the difficulties heretofore attendant upon efforts made to secure satisfactory disinfection at low temperatures, it was thought advisable to use in all cases the maximum amount of formaldehyde employed in previous experiments. (See page 19). Through an error of calculation, however, made after the completion of the second test, the amounts were diminished, but, as will be noted, the results were unchanged. Whether success would have been attained had the amounts used been further decreased, it is impossible to say. However, a further decrease is not necessitated for reasons of economy nor can it be recommended. The quantities of formaldehyde and potassium permanganate to be used at varying temperatures are set forth on page 27.

"The true principle of disinfection is to attack the specific poisons of disease at their seats of origin as far as these are accessible to us."—*Notter-Horrocks.*

"It is a maxim universally agreed upon in agriculture, that nothing must be done too late; and again, that everything must be done at its proper season, while there is a third precept which reminds us that opportunities lost can never be regained."—*Pliny.*

RESULTS OF EXPERIMENTS AT LOW TEMPERATURES.

Formaldehyde—Potassium Permanganate Method.

Number of experiment.	Temperature of room—beginning	Temperature of room—ending	Mean temperature day outdoors	Character of day.	Relative humidity	Vapor pressure	Precipitation in inches	Formaldehyde, per 1,000 cubic feet	Bacillus anthracis	Bacillus subtilis	Bacillus typhosus	Bacillus coli communis	Bacillus prodigiosus	Staph. pyogenes albus	Staph. pyogenes aureus	Control
1	20 F	26 F	12	Partly cloudy	55%	.041	.0	32 oz.	Neg.	Neg.	Neg.	....	....	Neg.	....	Pos.
2	12	20	10	Clear	62%	.036	.0	32	Neg.	Neg.	Neg.	....	....	Neg.	....	Pos.
3	14	23	22	Clear	66%	.070	.0	24	Neg.	Neg.	Neg.	....	....	Neg.	....	Pos.
4	14	22	22	Partly cloudy	68%	.074	Tr.	24	Neg.	Neg.	Neg.	....	....	Neg.	....	Pos.
5	14	24	17	Clear	64%	.054	.0	24	Neg.	Neg.	Neg.	....	....	Neg.	....	Pos.
6	35	38	28	Cloudy	70%	.137	Tr.	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
7	35	39	40	Clear	82%	.184	.0	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
8	46	51	46	Partly cloudy	83%	.228	.0	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
9	34	41	26	Clear	72%	.089	.0	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
10	26	38	24	Partly cloudy	77%	.096	.0	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
11	43	47	42	Partly cloudy	69%	.143	Tr.	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
12	33	39	30	Cloudy	62%	.089	.39	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
13	12	27	18	Partly cloudy	78%	.047	.11	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.
14	23	31	23	Cloudy	91%	.108	.34	24	Gth.	Gth.	Neg.	Gth.	Neg.	....	Neg.	Pos.
15	27	34	25	Cloudy	85%	.113	.01	24	Neg.	Neg.	Neg.	Neg.	Neg.	....	Neg.	Pos.

NOTE—In the foregoing experiments all inoculated slips were placed in several layers of flannel.

RESULTS OF EXPERIMENTS AT LOW TEMPERATURES WITH DRIED SPECIMENS.

Formaldehyde—Potassium Permanganate Method.

Number of experiment.	Temperature of room—beginning.	Temperature of room—ending	Mean temperature of day out doors	Character of day.	Relative humidity	Vapor pressure	Precipitation in inches	Method of exposure.	Bacillus anthracis	Bacillus subtilis	Bacillus typhosus	Bacillus coli communis	Bacillus prodigiosus	Staphy. pyogenes aureus	Controls	Specimens dried—(in hours.)
1	20F	34F	18	Clear	85%	.052	.0	Slips in books	....	Gth.	Gth.	....	....	Gth.	Pos.	....
								Slips under carpet	Neg.	....	....	Neg.	Neg.	....	Pos.	....
								Wood skewers	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.	....
2	46	47	49	Cloudy	97%	.322	.67	Slips in books	Gth.	....	....	Gth.	Gth.	....	Pos.	24 hours.
								Under carpet	....	Gth.	Neg.	....	....	Neg.	Pos.	24 hours.
								Wood skewers	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.	24 hours.
3	21	34	23	Clear	61%	.057	.0	Slips in books	....	Gth.	Gth.	....	....	Gth.	Pos.	48 hours.
								Under carpet	Gth.	....	....	Gth.	Gth.	....	Pos.	48 hours.
								Wood skewers	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.	48 hours.
4	29	37	25	Partly cloudy	68%	.063	.0	Slips in books	Gth.	....	....	Gth.	Gth.	....	Pos.	72 hours.
								Under carpet	....	Gth.	Neg.	....	....	Gth.	Pos.	72 hours.
								Wood skewers	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.	72 hours.
5	28	38	28	Cloudy	78%	.093	.05	Slips in books	....	Gth.	Gth.	....	....	Gth.	Pos.	96 hours.
								Under carpet	Neg.	....	....	Neg.	Gth.	....	Pos.	96 hours.
								Wood skewers	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.	96 hours.

NOTE—In the foregoing experiments 24 ounces of formaldehyde solution were used to each 1,000 cubic feet of air space.

Final Recommendations.

The Illinois State Board of Health now recommends formaldehyde as an aerial disinfectant, when used in combination with potassium permanganate, in the manner described in this circular.

The following quantities of chemicals should be used for each 1,000 cubic feet of air space:

Temperature above 60° F.—Formaldehyde (40%), 16 ounces.
Potassium permanganate 6¾ ounces.
Temperature below 60° F.—Formaldehyde (40%) 24 ounces.
Potassium permanganate 10 ounces.

The following suggestions are important and may prevent failure in the application of this method of disinfection.

1. Good formaldehyde is essential to success. Reliable formaldehyde or formalin is not very expensive; poor formaldehyde is dear at any price. (See remarks on pages 14 and 18.) Get the best!
2. The permanganate of potassium must be in powdered form, or in long needle shaped crystals. If the large octahedral crystals are purchased, they must be powdered before use. Get the best!
3. The retention of the heat caused by the reaction of the combined chemicals is necessary to the generation of a large volume of gas. Hence it is necessary that the metal container or generator be covered with asbestos, or with a non-conductive outer vessel.
4. As the union between the chemicals causes much frothing and effervesence, large vessels are necessary to prevent the solution from running over. The amounts of the chemicals set forth on page 21 should never be exceeded in vessels of the size mentioned.
5. The formaldehyde solution must be poured upon the potassium permanganate. The potassium permanganate must *not* be dropped into the formaldehyde. (See page 21.)
6. The room should be sealed so as to prevent the escape of gas. (See page 7.)
7. Clothing, bedding, etc. must be treated as described on page 7.
8. It is always well to wash the wood surfaces of the room, as described on page 7. It is absolutely necessary to do so when such surfaces have been soiled by the sputum or any other discharges of the patient.
9. It is *not* practicable to disinfect books with formaldehyde.

In conclusion, the State Board of Health earnestly advises and urges health officials, physicians and all others who may be called upon to perform disinfection, to adopt the method of aerial disinfection recommended herein, and to abandon the use of all other methods.

Published by order of the State Board of Health.

James A. Egan, M. D., Secretary.

June 1, 1906.

STANDARD DISINFECTANTS.

The following are simple, cheap and most reliable Disinfectants:

Standard Disinfectant No. 1.

Four per cent Solution of Chloride of Lime.

Dissolve Chloride of Lime of the best quality, in water, in proportions of six ounces of lime to one gallon of water.

This is one of the strongest disinfectants known. Discharges from the bowels of a patient suffering from a contagious or infectious disease, should be received in a vessel containing this solution, and allowed to stand for an hour or more before being thrown into the vault or water closet. Discharges from the throat or lungs should be received in a vessel containing this solution.

Chloride of Lime in powder may be used freely in privy vaults, cess pools, drains, sinks, etc.

Instead of the solution of chloride of lime, carbolic acid may be used for the same purposes, in a strength of 6½ ounces to the gallon of water. This makes a five per cent solution of carbolic acid.

Standard Disinfectant No. 2.

Bichloride of Mercury, 1-500.

Dissolve Corrosive Sublimate and Muriate of Ammonia in water, in the proportion of two drachms (120 grains—¼ ounce) of each to the gallon of water. Dissolve in a wooden tub, barrel or an earthen crock.

Use for the same purpose and in the same way as No. 1. Equally effective but slower in action, so that it is necessary to let the mixture (disinfectant and infected material) stand about four hours before disposing of it. This solution is odorless, while the chloride of lime solution is often objectionable in the sick room on account of its smell.

Standard Disinfectant No. 3.

Bichloride of Mercury, 1-1000.

Dissolve one drachm (60 grains—⅛ ounce) each of Corrosive Sublimate and Muriate of Ammonia in one gallon of water. Dissolve in a wooden tub, barrel or pail or earthen crock.

Used for the disinfection of soiled underclothing, bed linen, etc. Immerse the articles for four hours, then wring them out and boil them. This solution is excellent for wetting the floors of offices, stores, workshops, halls and school rooms before sweeping.

Mixed with an equal quantity of water this solution is useful for washing the hands and general surfaces of the bodies of attendants.

☞ Chloride of lime, carbolic acid and corrosive sublimate are deadly poisons.

Milk of Lime (Quicklime).

Slack a quart of freshly-burnt lime (in small pieces) with three-fourths of a quart of water—or, to be exact, 60 parts of water by weight with 100 of lime. A dry powder of slack lime (hydrate of lime) results. Make milk of lime not long before it is to be used by mixing one part of this dry hydrate of lime with eight parts (by weight) of water.

Air-slacked lime is worthless. The dry hydrate may be preserved some time if it is enclosed in an air-tight container. Milk of lime should be freshly prepared, but may be kept a few days if it is closely stoppered.

Quicklime is one of the cheapest of disinfectants. This solution can take the place of chloride of lime, if desired It should be used freely, in quantity equal in amount to the material to be disinfected. It can be used to whitewash exposed surfaces, to disinfect excreta in the sick room or on the surface of the ground, in sinks, drains, stagnant pools.

ADDENDA.

(Do not in any manner modify the "Final Recommendations" on page 27.)

While the foregoing circular on "Practical Disinfection" was in press, the Secretary submitted the proof sheets containing the announcement of results of the experiments with the formaldehyde-potassium permanganate method, to a prominent bacteriologist who had previously manifested great interest in the workings of the State Board of Health, and requested that he examine into the technique followed in the experiments, not only in the laboratory but in the apartment in which disinfection was attempted, and pass an opinion on the same and the results obtained. This gentleman offered no criticism on the process followed, but while expressing the belief that the method of disinfection recommended was dependable at all times, he strongly advised that further experiments be conducted in order to definitely determine whether the growth of the cultures exposed had not been simply inhibited. He cited experiments made by other sanitary authorities in which it was reported that no growth was found until after the seventh day, when the growth was abundant. In short, he inclined to the view that possibly the exposed cultures which had been kept in the incubator for two days (see pages 17 and 23) had not been killed, that the growth had merely been retarded; that if the cultures had been kept in the incubator for ten days instead of two the results might have been different.

The Secretary immediately laid the matter before another bacteriologist equally prominent and requested an opinion, which was given in the following terse remarks:

> A true growth appears in one or two days as a rule. Never heard of a growth at ten days. An inhibited growth is, in practical effect, no growth. Moulds are not growths. Contamination is too often mistaken for a growth.

We believe that the gentleman last quoted struck the key note when he said "an inhibited growth is, in practical effect, no growth."

Rosenau probably entertained the same opinion when he said in his work on Disinfection and Disinfectants:

> As a matter of fact it is not necessary actually to destroy the infective agents; it is quite sufficient to render them incapable of causing or conveying disease. For example, if the micro-organisms are so attenuated that they have lost their virulence, or if they are so scattered that they are too few to cause infection, the object of disinfection has been accomplished.

While feeling assured that a growth in the incubator, in which all conditions were favorable, would not necessarily indicate the survival of bacteria in the infected room in which many conditions were unfavorable; that a retarded growth in the incubator would indicate "organisms so attenuated that they have lost their virulence;" that

such organisms, if existing in the infected room after disinfection, would have their activity destroyed by free exposure to currents of fresh air and possible sunlight, to say nothing of the housewife's mop and broom; the Secretary resolved to follow the recommendation made and conduct further experiments, in order to determine whether the growth of the cultures had not been simply inhibited, and gave directions that the publication of this circular be delayed.

The following is an epitomized account of the experiments conducted under the direct supervision of the Secretary and Assistant Secretary:

Experiment Number 1, June 30, 1906.

Bacteriologists, Dr. H. C. Blankmeyer and Mr. W. J. Hoyt.

Room 3,500 cubic feet, as in previous experiments. Formaldehyde, 24 ounces per 1,000 cubic feet. Temperature, 75°F. Relative humidity, 56%. Room kept closed for six hours.

Test organisms, B. anthracis, B. coli com., B. typhosis and S. pyogenes aureus, freshly dried specimens on skewers and slips. Laboratory technique as on page 23. Ten days period of incubation.

No growth. Contamination in some tubes.

Experiment Number 2, July 2, 1906.

Bacteriologists, Dr. H. C. Blankmeyer and Mr. W. J. Hoyt.

Room as in Experiment number 1. Formaldehyde, 16 ounces per 1,000 cubic feet. Temperature 76°F. Relative humidity, 58%. Room kept closed for six hours.

Test organisms, laboratory technique and incubation as in Experiment number 1.

No growth. Contamination in some tubes.

Experiment Number 3, July 9, 1906.

Bacteriologists, Dr. H. C. Blankmeyer and Mr. W. J. Hoyt.

Cold storage warehouse. Room capacity, 2,500 cubic feet. Formaldehyde, 32 ounces per 1,000 cubic feet. Temperature 38°F. Relative humidity, 78%. Room kept closed for six hours.

Test organisms, laboratory technique and period of incubation as in Experiment number 1.

No growth. Contamination in a few tubes.

Experiment No. 4, July 11, 1906.

Bacteriologists, Dr. H. C. Blankmeyer and Mr. W. J. Hoyt.

Cold storage warehouse. Room as in Experiment No. 3. Formaldehyde 24 oz. per 1,000 cubic feet. Temperature 38° F. Relative humidity 85%. Room kept closed for 6 hours.

Test organisms, laboratory technique and period of incubation as in Experiment No. 1.

No growth. Contamination in some tubes.

Experiment No. 5, July 16, 1906.

Bacteriologists, Dr. H. C. Blankmeyer and Mr. W. J. Hoyt.

Room as in Experiment No. 1. Formaldehyde 24 oz. per 1,000 cubic feet. Temperature 72° F. Relative humidity 59%. Room kept closed for 6 hours.

Test organisms, laboratory technique and period of incubation as in Experiment No. 1.

No growth.

Experiment No. 6, July 17, 1906.

Bacteriologists, Dr. H. C. Blankmeyer, Mr. W. J. Hoyt and Dr. W. H. Buhlig.

Room as in Experiment No. 1. Formaldehyde 16 oz. per 1,000 cubic feet. Temperature of room 68° F. Relative humidity 79%. Room kept closed for 6 hours.

Test organisms. B. anthracis, B. coli com., S. pyogenes aureus. Freshly dried specimens on skewers and slips. Laboratory technique as on page 23. Incubation 8 days. Results:

B. anthracis. No growth.

S. pyogenes aureus. No growth.

B. coli com. Slight growth (questionable).

Dr. Buhlig, who was called from Chicago to assist in these experiments, devoted several days time to the examination of the cultures and controls used in Experiment No. 6.

Experiment No. 7, August 5, 1906.

Bacteriologists Drs. W. H. Buhlig and H. C. Blankmeyer.

Room as in Experiment No. 1. Formaldehyde 24 oz. per 1,000 cubic feet. Temperature 80° F. Relative humidity 76%. Room kept closed for six hours.

Test organisms B. anthracis, B. coli com. B. typh. B. diphtheria and S. pyogenes aureus, freshly dried specimens, (24, 48, 72 and 96 hours) dried on skewers and slips of milk paper, also skewers and papers freshly dipped. Uninoculated slips and skewers were also exposed to the action of the gas in the room, and inserted in freshly infected bouillon tubes to determine whether the absorbed formaldehyde could in any manner influence the results. All possible aseptic precautions were taken to insure correct interpretations. Period of incubation eleven days.

No growth.

Experiment No. 8, August 6, 1906.

Bacteriologists Drs. W. H. Buhlig and H. C. Blankmeyer.

Room as in Experiment No. 1. Formaldehyde 16 oz. per 1,000 cubic feet. Temperature 78° F. Relative humidity 76%. Room kept closed for six hours.

Test organisms and laboratory technique as in Experiment No. 6. Period of incubation twelve days.

No growth.

Experiment No. 9, August 12, 1906.

Bacteriologist Dr. H. C. Blankmeyer.

Room as in Experiment No. 1. Formaldehyde 16 oz. per 1,000 cubic feet. Temperature 76° F. Relative humidity 54%. Room kept closed for six hours.

Test organisms and laboratory technique as in Experiment No. 6. Period of incubation ten days. Results, no growth except in case of S. pyog. aureus on seventy-two hour slips only.

EXPERIMENT NO. 10, AUGUST 29.

Bacteriologists Drs. H. C. Blankmeyer and W. G. Bain.

Room as in Experiment No. 1. Formaldehyde 16 oz. per 1,000 cubic feet. Temperature 72°F. Relative humidity 56%. Room kept closed for six hours.

Test organisms B. anthracis and B. subtilis, freshly dried specimens (24, 48, 72 and 96 hours) dried on skewers and slips of milk paper, also skewers and papers freshly dipped. Period of incubation four days.

No growth. All control tubes showed growth except skewers of anthrax dried ninety-six hours.

In all experiments, an examination of the controls was made to confirm the growth of the microorganisms.

Seven hundred and ninety-four test objects were exposed in Experiments Nos. 1 to 10.

It will be noted that in Experiment No. 9 the most resistant bacilli (*B. anthracis and B. subtilis*) only were used. The fact that these were uniformly killed would alone almost conclusively prove the efficacy of this method of disinfection.

In view of the results obtained in the foregoing experiments and in the fifty previously conducted, the Illinois State Board of Health again recommends formaldehyde as an aerial disinfectant when used in combination with potassium permanganate in the method described in this circular. The State Board of Health also unhesitatingly pronounces this method of disinfection, one on which dependence can be placed under all conditions of temperature and humidity.

JAMES A. EGAN, M. D.
Secretary.

September 10, 1906.

"Indeed, what is there that does not appear marvellous when it comes to our knowledge for the first time? How many things, too, are looked upon as quite impossible until they have been actually effected?"—*Pliny.*